REMARKS

Based on the Amendment presented above and the following Remarks, Applicant requests reconsideration of the objection to Claim 20, the rejection of Claims 1, 2, 5, 8, 9, 11, 21-23, 27, and 28 under 35 U.S.C. 102(b), and the rejection of Claims 1, 2, 4, 5, 7-11, 24, 25, 27-29, 31, and 32 under 35 U.S.C. 103(a).

Claims 3, 6, 12-20, and 30 have been objected to as being dependent on a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 26 has been allowed.

Objection to Claim 20

Claim 20 has been objected to for the informality wherein "refrigerant" is repeated at line 7. The claim has been amended to correct this informality, and it is requested that the objection be withdrawn.

Rejection of Claims 1, 2, 5, 8, 9, 11, 21-23, 27, and 28 under 35 U.S.C. 102(b)

Claims 1, 2, 5, 8, 9, 11, 21-23, 27, and 28 have been rejected as being anticipated under 35 U.S.C. 102(b) by German Patent No. DE 101 08 905 A1 to Linde AG ("the '905 patent").

The '905 patent discloses a method for the liquefaction of a two-component gas mixture wherein the gas mixture is compressed in compressor K1 (Fig. 3), the compressed gas mixture is divided into a first stream and a second stream, the first stream is cooled in heat exchanger W1 with refrigeration provided by work expansion in expander X1 of a portion of the first stream, the second stream is cooled in heat exchanger W3, and the cooled first and second streams are combined and further cooled in heat exchanger W3. This cooled combined stream is reduced in pressure across throttling valve V1 and separated in separator A1 into a vapor stream and a liquid stream. Refrigeration in heat exchanger W3 is provided by a work expansion refrigeration system utilizing a refrigerant obtained as the vapor stream from the

separator A1 wherein the refrigerant is compressed in compressor K2 and cooled in heat exchanger W2. A first portion of the cooled compressed refrigerant is withdrawn from an intermediate point in heat exchanger W2 and work expanded in expanders X2 and X3 to provide refrigeration for heat exchangers W2 and W3. A second portion is further cooled in heat exchangers W2 and W3 to provide a further cooled compressed refrigerant.

The liquid stream from separator A1 is further cooled in heat exchanger W4 and flows to mixer M1, a first portion of the further cooled compressed refrigerant from heat exchanger W3 is reduced in pressure across throttling valve V2 and flows to mixer M1, the two streams are mixed therein, and the mixed stream flows to product storage tank T1. The second portion of the further cooled compressed refrigerant from heat exchanger W3 is reduced in pressure across throttling valve V3, and the throttled reduced-pressure stream provides the refrigeration in heat exchanger W4. The refrigerant from heat exchanger W4 is combined with work expanded refrigerant from expander X3 and the vapor from separator A1, and the combined stream is warmed in heat exchanger W3.

The embodiments of Claims 1, 2, 5, 8, 9, 11, 21-23 include a method for gas liquefaction comprising

(a) cooling a feed gas in a first heat exchange zone by indirect heat exchange with one or more refrigerant streams provided in a first refrigeration system, and withdrawing a substantially liquefied stream from the first heat exchange zone;

(b) further cooling the substantially liquefied stream in a second heat exchange zone by indirect heat exchange with one or more work-expanded refrigerant streams provided by a second refrigeration system and withdrawing a further cooled, substantially liquefied stream from the second heat exchange zone; and

(c) work expanding two or more cooled compressed refrigerant streams in the second refrigeration system to provide at least one of the one or more work-expanded refrigerant streams in the second heat exchange

zone, wherein the operation of the second refrigeration system includes the steps of

(1) compressing one or more refrigerant gases to provide a compressed refrigerant stream;

(2) cooling all or a portion of the compressed refrigerant stream in a third heat exchange zone to provide a cooled, compressed refrigerant stream; and

(3) work expanding the cooled, compressed refrigerant stream to provide one of the one or more work-expanded refrigerant streams.

The flow rate of a work-expanded refrigerant stream in the second heat exchange zone is less than the total flow rate of one or more work-expanded refrigerant streams in the third heat exchange zone.

The embodiments of Claims 27 and 28 comprise a system for carrying out the method of Claim 1.

Heat exchanger W3 (Fig. 3) of the '905 patent corresponds to the claimed first heat exchange zone (i.e., 21 of Fig. 1) because both heat exchange steps cool and partially liquefy ('905) or substantially liquefy (Claim 1) the feed gas. Heat exchanger W4 (Fig. 3) of the '905 patent is analogous to the claimed second heat exchange zone (i.e., 27 of Fig. 1) because both heat exchange steps further cool components of the feed steam following the initial cooling step. Heat exchanger W2 of the '905 patent corresponds to the claimed third heat exchange zone (e.g., 63 of Fig. 1) because both heat exchange steps cool compressed refrigerant by heat exchange with work-expanded refrigerant.

The claimed embodiments differ from the disclosure of the '905 patent in the following ways:

(1) In claimed step (b), the substantially liquefied stream (i.e., stream 25 of Figs. 1-8) is cooled in the second heat exchange zone by indirect heat exchange with one or more work-expanded refrigerant streams. In the '905 patent, the stream cooled in analogous heat exchanger W4 is the liquid stream from separator A1, which means that only a portion of the cooled feed stream from heat exchanger W3 is cooled in heat exchanger W4. Refrigeration for this cooling is provided by reducing the pressure of the second portion of the refrigerant stream from heat exchanger W3 across throttling valve V3 and passing the throttled reduced-pressure stream through heat exchanger W4. Thus there are two distinct differences between the claimed embodiments and the '905 patent, namely,

(1)(a) the streams cooled in claimed step (b) and in analogous heat exchanger W4 are different streams, i.e., have different compositions and flow rates, and

(1)(b) the work-expanded refrigerant provided in claimed step (b) is not a throttled reduced-pressure refrigerant as provided to heat exchanger W4.

(2) In the claimed embodiment, the flow rate of a work-expanded refrigerant stream in the second heat exchange zone is less than the total flow rate of one or more work-expanded refrigerant streams in the third heat exchange zone. The '905 patent, however, has no work-expanded refrigerant in analogous heat exchanger W4; instead, the refrigerant stream is a throttled reduced-pressure refrigerant.

Because of these clear differences, the claimed embodiments are not identically disclosed by the '905 patent and therefore are not anticipated by the '905 patent under 35 U.S.C. 102 (b). It is respectfully requested that the rejection of Claims 1, 2, 5, 8, 9, 11, 21-23, 27, and 28 under 35 U.S.C. 102 (b) over the '905 patent be withdrawn.

Rejection of Claims 1, 2, 4, 5, 7-11, 24, 25, 27-29, 31, and 32 under 35 U.S.C. 103(a)

Claims 1, 2, 4, 5, 7-11, 24, 25, 27-29, 31, and 32 have been rejected under 35 U.S.C. 103 (a) as being unpatentable over U.S. Patent 4,755,200 to Y. Liu et al. ("Liu") in view of the '905 patent.

Liu discloses a process for natural gas liquefaction in which a single component refrigeration cycle is added to a single or dual mixed refrigeration cycle to precool the natural gas prior to adsorptive drying. A prior art process is illustrated in Fig. 1 wherein the feed gas is precooled and pretreated to remove water and heavier hydrocarbons. The pretreated feed gas is further cooled and totally condensed in the first bundle of main heat exchanger 14, and the condensed feed is subcooled in the second bundle of the heat exchanger (column 4, lines 20-26). Refrigeration is provided to heat exchanger 14 by a vaporizing mixed refrigerant in a low level refrigeration system as shown. Compressed mixed refrigerant in the low level refrigeration system is cooled by vaporizing mixed refrigerant in a high level refrigeration system in a heat exchange zone comprising heat exchangers 26, 28, 30, and 32.

The process of Fig. 1 is modified by two improvements as shown in Fig. 2. In one improvement, the feed is precooled in heat exchanger 100 by a single-component closed-loop vaporizing refrigeration system prior to pretreatment. In the second improvement, cooling of the single-component refrigerant after compression is provided by a refrigerant sidestream from the high level refrigeration system. Fig. 2 is identical to Fig. 1 in all other features. An improvement to a single mixed refrigerant liquefaction system is shown in Fig. 3 wherein the feed gas is precooled in heat exchanger 200 by a single-component closed-loop vaporizing refrigeration system prior to pretreatment. Cooling of the compressed single component refrigerant 290 is provided by the mixed refrigerant in the warm end of main heat exchanger 214.

The disclosure of the '905 patent and the differences between the claimed embodiments and the '905 patent are summarized above.

The embodiments of Claims 1, 2, 4, 5, and 7-11 include a method for gas liquefaction comprising

(a) cooling a feed gas in a first heat exchange zone by indirect heat exchange with one or more refrigerant streams provided in a first refrigeration system, and withdrawing a substantially liquefied stream from the first heat exchange zone;

(b) further cooling the substantially liquefied stream in a second heat exchange zone by indirect heat exchange with one or more work-expanded refrigerant streams provided by a second refrigeration system and withdrawing a further cooled, substantially liquefied stream from the second heat exchange zone; and

(c) work expanding two or more cooled compressed refrigerant streams in the second refrigeration system to provide at least one of the one or more work-expanded refrigerant streams in the second heat exchange zone, wherein the operation of the second refrigeration system includes the steps of

(1) compressing one or more refrigerant gases to provide a compressed refrigerant stream;

(2) cooling all or a portion of the compressed refrigerant stream in a third heat exchange zone to provide a cooled, compressed refrigerant stream; and

(3) work expanding the cooled, compressed refrigerant stream to provide one of the one or more work-expanded refrigerant streams.

The flow rate of a work-expanded refrigerant stream in the second heat exchange zone is less than the total flow rate of one or more work-expanded refrigerant streams in the third heat exchange zone.

The embodiments of Claims 27-29 comprise a system for carrying out the method of Claim 1.

The claimed embodiments differ from the disclosure of Liu because the claimed method uses work expansion refrigeration for final cooling of the liquefied gas (i.e., heat exchange zone 27 of Fig. 1). In contrast, Liu uses a low level mixed refrigerant system for final cooling of the liquefied gas in which liquefied refrigerant is vaporized in main heat exchanger 14 in a low level refrigeration system. No work expansion refrigeration is used by Liu.

In comparing the disclosure of Liu with the claimed embodiments, Liu's heat exchangers 100 (Fig. 2) and 200 (Fig. 3) are analogous to the claimed first heat exchange zone, and Liu's main heat exchangers 14 (Fig. 2) and 214 (Fig. 3) are analogous to the claimed second heat exchange zone. Liu's process differs from the claimed process because the feed gas is not liquefied in heat exchangers 100 and 200. This is described for the embodiment of Fig. 2 at column 8, lines 1-3, where it is stated that the feedstream is cooled to 66.3 °F in heat exchanger 100. Further, it is stated at column 4, lines 21-23 that the natural gas (i.e., feed gas) is cooled and totally condensed in the first bundle of main heat exchanger 14. Regarding the embodiment of Fig. 3, cleanup stations 211 and 213 correspond to cleanup stations 11 and 13 of Fig. 2.

Thus the feed stream is not liquefied in Liu's heat exchangers 100 and 200. In the claimed embodiments, however, the feed gas is substantially liquefied in the first heat exchange zone. Since Liu's heat exchangers 100 and 200 are analogous to the claimed first heat exchange zone, there is a clear difference between Liu's disclosure and the claimed embodiments.

The '905 patent and Liu both disclose cooling the feed gas successively through first and second heat exchangers or heat exchange zones. A comparison of Fig. 3 of the'905 patent and Figs. 2 and 3 of Liu shows that heat exchanger W3 of the '905 patent corresponds to heat exchangers 100 and 200 of Liu. Partial condensation of the feed gas occurs in the '905 heat exchanger W3 and is required in order to generate the vapor stream in separator A1 that provides the refrigerant for

the gas expander refrigeration system. As pointed out above, however, no condensation or liquefaction occurs in Liu's heat exchangers 100 and 200. The skilled person would find no motivation in either the '905 patent and Liu to combine these two disclosures. The skilled person would realize that if the disclosures were combined, Liu's requirement of no liquefaction in the first heat exchanger would render the process of the '905 patent inoperable because there would be no refrigerant available for the work expander refrigeration system. Conversely, the '905 patent requirement of partial condensation in the first heat exchanger would render the Liu process totally or partially inoperable, because the temperatures required to condense the feed gas in heat exchangers 100 and 200 would freeze water contained in the feed gas prior to cleanup stations 11 and 13 or 211 and 213.

The Examiner suggests that it would have been obvious to one of ordinary skill in the art to modify the system of Liu by work expanding the refrigerant to recover energy which may be lost and to have a higher refrigerant flow rate of the second refrigerant through the third heat exchanger than the second heat exchanger. Applicant respectfully disagrees and points out that even if Liu's refrigerant were work expanded as taught in the '905 patent, it would not change Liu's requirement that the feed gas is liquefied in the second heat exchange zone and not in the first heat exchange zone. In the claimed embodiments, the feed gas is substantially liquefied in the first heat exchange zone.

For the reasons given above, it is respectfully submitted that the Examiner has not clearly established that Claims 1, 2, 4, 5, 7-11, and 27-29 are unpatentable under 35 U.S.C. 103 (a) over Liu in view of the '905 patent.

Claims 24 and 25 define the embodiment of Fig. 9, which is a method for gas liquefaction wherein a feed gas is cooled and substantially liquefied in a first heat exchange zone by indirect heat exchange with one or more refrigerants provided in a first refrigeration system, the substantially liquefied stream is further cooled in a second heat exchange zone by indirect heat exchange with a cold work-expanded refrigerant. The cold work-expanded refrigerant is provided in a second refrigeration

system comprising at least two refrigeration circuits by compressing a refrigerant gas in a first refrigeration circuit to provide a compressed refrigerant gas; cooling the compressed refrigerant gas in a third heat exchange zone to provide a cooled, compressed refrigerant gas, wherein a portion of the cooling is provided therein by vaporizing a multicomponent refrigerant provided by a second refrigeration circuit; work expanding the cooled, compressed refrigerant gas to provide the cold work-expanded refrigerant; and warming the cold work-expanded refrigerant in the second heat exchange zone to provide refrigeration therein for cooling the substantially liquefied stream from the first heat exchange zone and to provide refrigeration for cooling the compressed refrigerant gas in the third heat exchange zone, and withdrawing therefrom a warmed refrigerant to provide the refrigerant gas. Claims 31 and 32 describe a system for carrying out the method of Claims 24 and 25.

The embodiments of Claims 24, 25, 31, and 32 differ significantly from the disclosures of Liu and the '905 patent as summarized below.

The claimed embodiments differ from Liu in that (1) Liu does not liquefy the feed gas in the first heat exchanger, while in contrast the claimed embodiment requires that the feed gas be substantially liquefied in the first heat exchange zone and (2) Liu cools and liquefies the feed gas in the second heat exchanger by a vaporizing multicomponent refrigeration system while, in contrast, the claimed embodiment further cools the liquefied gas in the second heat exchange zone by work expansion refrigeration wherein the compressed refrigerant is cooled prior to work expansion by vaporizing a multicomponent refrigerant provided by a second refrigeration circuit.

Heat exchanger W3 (Fig. 3) of the '905 patent corresponds to the claimed first heat exchange zone (i.e., 21 of Fig. 9) because both heat exchange steps cool and partially liquefy ('905) or substantially liquefy (Claims 24 and 27) the feed gas. Heat exchanger W4 (Fig. 3) of the '905 patent is analogous to the claimed second heat exchange zone following heat exchange zone 21 of Fig. 9 because both heat exchange steps further cool components of the feed steam following the initial

cooling step. Heat exchanger W2 of the '905 patent corresponds to the claimed third heat exchange zone (i.e., the heat exchange zone that cools compressed refrigerant 901 in Fig. 9) because both heat exchange steps cool compressed refrigerant by heat exchange with work-expanded refrigerant.

The claimed embodiments differ significantly from the disclosure of the '905 patent. In claimed step (b), the substantially liquefied stream from heat exchanger 21 of Fig. 9 is cooled in the second heat exchange zone by indirect heat exchange with a work-expanded refrigerant stream. In the '905 patent, the stream cooled in analogous heat exchanger W4 is the liquid stream from separator A1, which means that only a portion of the cooled feed stream from heat exchanger W3 is cooled in heat exchanger W4. Refrigeration for this cooling is provided by reducing the pressure of the second portion of the refrigerant stream from heat exchanger W3 across throttling valve V3 and passing the throttled reduced-pressure stream through heat exchanger W4. Thus there are three distinct differences between the claimed embodiments and the '905 patent, namely,

(a) the streams cooled in claimed step (b) and in analogous heat exchanger W4 are different streams, i.e., have different compositions and flow rates,

(b) the work-expanded refrigerant provided in claimed step (b) is not a throttled reduced-pressure refrigerant as provided to heat exchanger W4, and

(c) the refrigeration for cooling the compressed refrigerant in the third heat exchange zone as claimed is provided by a combination of work expansion refrigeration and vaporization a multicomponent refrigerant provided by a second refrigeration circuit, whereas the refrigeration in analogous heat exchanger W2 is provided only by work expansion refrigeration.

The '905 patent and Liu both disclose cooling the feed gas successively through first and second heat exchangers or heat exchange zones. A comparison of Fig. 3 of the'905 patent and Figs. 2 and 3 of Liu shows that heat exchanger W3 of the

'905 patent corresponds to heat exchangers 100 and 200 of Liu. Partial condensation of the feed gas occurs in the '905 heat exchanger W3 and is required in order to generate the vapor stream in separator A1 that provides the refrigerant for the gas expander refrigeration system. As pointed out above, however, no condensation or liquefaction occurs in Liu's heat exchangers 100 and 200. The skilled person would find no motivation in either the '905 patent and Liu to combine these two disclosures. The skilled person would realize that if the disclosures were combined, Liu's requirement of no liquefaction in the first heat exchanger would render the process of the '905 patent inoperable because there would be no refrigerant available for the work expander refrigeration system. Conversely, the'905 patent requirement of partial condensation in the first heat exchanger would render the Liu process totally or partially inoperable, because the temperatures required to condense the feed gas in heat exchangers 100 and 200 would freeze water contained in the feed gas prior to cleanup stations 11 and 13 or 211 and 213.

The Examiner suggests that it would have been obvious to one of ordinary skill in the art to modify the system of Liu by work expanding the refrigerant to recover energy which may be lost and to have a higher refrigerant flow rate of the second refrigerant through the third heat exchanger than the second heat exchanger. Applicant respectfully disagrees and points out that even if Liu's refrigerant were work expanded as taught in the '905 patent, it would not change Liu's requirement that the feed gas is liquefied in the second heat exchange zone and not in the first heat exchange zone. In the claimed embodiments, the feed gas is substantially liquefied in the first heat exchange zone.

For the reasons given above, it is respectfully submitted that the Examiner has not clearly established that Claims 24, 25, 31, and 32 are unpatentable under 35 U.S.C. 103 (a) over Liu in view of the '905 patent.

Summary

In view of the amendment and arguments submitted above, Applicant requests that the Examiner withdraw the objection to Claim 20, the rejection of Claims 1, 2, 5,

8, 9, 11, 21-23, 27, and 28 as being anticipated under 35 U.S.C. 102(b) by the '905 patent, and the rejection of Claims 1, 2, 4, 5, 7-11, 24, 25, 27-29, 31, and 32 under 35 U.S.C. 103 (a) as being unpatentable over Liu in view of the '905 patent.

Because Claims 1, 27, and 29 are patentable for the reasons submitted above, the Examiner is requested to withdraw the objection to Claims 3, 6, 12-20, and 30 as being dependent on rejected base claims or any intervening claims.

A timely Notice of Allowance is requested for Claims 1-32.

Amendments to the Specification and Abstract will be made if needed when the final claims are allowed so that the descriptive matter is in harmony with the claims as allowed (MPEP 1302.01).

Prior art made of record and not relied upon is acknowledged.

Respectfully submitted,

Willard Jones II
Attorney for Applicants
Registration No. 31,172
7201 Hamilton Boulevard
Allentown, PA 18195-1501

(610) 481-4587

Attach: One Month Expention of Time